so that we finally have four equivalents which may then be combined into one resultant. This resultant will be the same as that obtained by the preceding graphic method, but it suggests a very different interpretation, viz, we do not think of a particle of air as having traveled continuously during the whole time to a very considerable distance away from the station, but rather consider it as having been kept at the station and successively subjected to these various hourly movements. From this point of view the resultant expresses what happened at the station to the wind vane and anemometer, and does not lead us to imagine that any great mass of air necessarily took part in the movements. This is a more rational interpretation, for every station is liable to have local peculiarities which must not be allowed to interfere with our interpretation of the general movements of the atmosphere in its neighborhood.

The total resultant above referred to considers all the observations made continuously hour by hour and day by day, but we may classify the observations by hours and compute the resultants for each hour separately. If we wish a total resultant, and are willing to base it upon only a few hourly resultants, we may select such hours as will give resultants that are approximately the same as those deduced from twenty-four hourly observations, and this is, approximately, what is done when we compute resultants from 8 a. m. and 8 p. m., as is done for the regular Table VIII of the MONTHLY WEATHER REVIEW. If, furthermore, experience should show that resultants computed by using the exact measured miles per hour differ but little from resultants computed by assuming that the average velocity of the wind is the same for all hours of the day, then one might be justified in omitting the labor of plotting or calculating the exact number of miles, since the defects of one hour would make up for the excesses of the next. This further simplification is especially allowable when, as in the computations for Table VIII, we restrict ourselves to an approximation deduced from two observations per day. The resultant winds given in Table VIII have not, thereby, lost in accuracy so much as we might at first thought anticipate. Their accuracy is quite comparable with that of the other meteorological elements with which they are likely to be compared, more especially the barometric gradients shown upon Chart No. IV, whose isobars are also based upon observations at 8 a. m. and 8 p. m.

The figures in the four principal columns of Table VIII are, therefore, deduced from the simple count of the frequency of the wind directions at 8 a. m. and 8 p. m., without having regard to the velocity or force of the wind; for instance, at Eastport, Me., the 60 observations during 30 days were distributed as follows: North, 10; northeast, 4; east, 4; southeast, 2; south, 10; southwest, 8; west, 8; northwest, 9; calm, 5. The four northeast winds are equivalent to 3 north and 3 east. Similarly, the southeast 2 are equivalent to 1 south and 1 east; the southwest 8 are equivalent to 5 south and 5 west; the northwest 9 are equivalent to 6 north and 6 west, so that if we add the four components we have north wind, 19; south wind, 16; east wind, 8; west wind, 19. The five calms do not affect the motion. The balance between north and south leaves north, 3; the balance between east and west leaves west, 11. Therefore, the resultant is a movement of 3 from the north and 11 from the west, which is the same as a movement of a little over 11 from the direction north 80° west.

The prevailing wind is determined by simply selecting that wind direction which occurs most frequently, that is to say, in the preceding case for Eastport, north and south would have an equal claim on our attention because both occurred 10 times, and the northwest would be almost on the same footing because it occurred 9 times. The prevailing wind does not convey to the mind any proper idea of the wind at a station unless some one direction occurs in an overwhelming majority of cases. The actual number of winds from each direction must be enumerated if we would have a datum that in any way replaces the resultant wind. Such a detailed statement is all the more important when there is a large number of winds alternately opposed to each other, thus in the case of strong land breezes by night and sea breezes by day, the resultant may be zero, or very small, whereas the statement of the frequency of each wind, or the analysis into the four principal components, gives one a clear idea of the alternate opposition of these breezes.—[C. A.]

FROST FORMATION IN ST. PAUL.

Mr. H. Volker, observer, Weather Bureau, St. Paul, Minn., has kindly forwarded to the Editor an account of an interesting case of frost formation. He submits a rough draft of the iron bridge across the Mississippi at Robert street. This bridge consists of iron framework, 870 feet long, as its southeastern portion and a similar framework, 330 feet long, as its northwestern portion. The central portion of the bridge is an iron truss, 340 feet long, resting on two slender stone pillars at 80 feet above low water. The central portion of the roadbed of the bridge is horizontal, while the roadbeds connecting this with the extremities have a gentle slope. Mr. Volker observed that on the early morning of September 20, when the minimum temperature at the Weather Bureau station was 38°:

> Not a sign of frost was to be seen on the level, central portion of the roadway, but on both inclines it was formed copiously, and, what was most remarkable, the line of frost extended up the inclines to the very point where the level portion begins, both on the northwest and on the southeast sides.

Mr. Volker states that the formation of frost was due not merely to the elevation and the cooling by radiation, but that—

> The sloping condition of the roadway was especially favorable for frost formation, and, if this had continued, frost would still have formed at a higher elevation, probably for hundreds and possibly for thousands of feet. From this I conclude that frost on sloping elevations, sides of hills and mountains, is formed in the same manner. If radiation and elevation were the only causes in such frost formations, then in this case frost should have disappeared gradually and not abruptly, for the elevation of the upper ends of the sloping roadways was equal to that of the level portion of the bridge.

We have no doubt that Mr. Volker is correct in attributing the abundant formation of frost on the sloping roadways to that inclination itself. Unless there were great differences in the velocity of the wind, the whole surface of the road, both horizontal and inclined, would cool down to about the same temperature during the nighttime, and the quantity of frost would depend principally upon the quantity of cold air flowing gently over the surface of the roadway. If there were no wind, then this quantity must have been much greater down the sloping approaches than along the central, level part, owing to the fact that the flow of air over the level portion is almost *nil*, while that down the slope is very appreciable. It can, however, happen that the slope may be too steep for the deposition of frost. Anyone can make the experiment by exposing at nighttime several wooden planks at a few feet above the ground, one of them horizontal, another slightly, and a third steeply inclined. There should be a raised rim on the edges of the planks, so as to force the air to flow downward the whole length of the planks. If, as we suppose, Mr. Volker's explanation is correct, the deposit of frost should be thickest on the plank that has a gentle slope.—[C. A.]

THE HANDBOOKS OF THE DEUTSCHE SEEWARTE.

One of the most important lines of practical work undertaken by the Deutsche Seewarte when reorganized in December, 1874, as a National Institute for Terrestrial Physics, was the preparation of an elaborate series of so-called "Sailing Directions," or handbooks for navigators sailing over the important commercial ocean routes. This great work has been accomplished, with a thoroughness characteristic of all Neumayer's works, by the successive publications of the "Segelhandbuch for the Atlantic Ocean," in 1885, and the "Atlas of 36 Charts" to accompany this in 1882; "Segelhandbuch for the Indian Ocean" in 1892, and "Atlas of 35 Charts" to accompany this in 1891; finally, the "Segelhandbuch for the Pacific Ocean," in 1897, and the "Atlas of 31 Charts" to accompany it in 1896. Meanwhile the accumulation of data has justified a revised edition of the Atlantic handbook, which will probably be published by the close of 1897. These three handbooks are treatises that summarize our knowledge of the three corresponding oceans and the atmosphere above them. The thirty or more charts give the latest details as to the depth of the ocean, its temperature, its currents, and specific gravity; the atmospheric temperature, pressure, winds, rains, cloudiness, and storms; the magnetic elements of declination, inclination, and intensity; finally, the principal routes for vessels, the whale fisheries, and other commercial matters. Each handbook of text, besides referring to its Atlas of Charts, also contains numerous additional special charts illustrating the minor details. To the meteorologist these handbooks are as valuable as to the navigator, since they make accessible to him the results of the studies of Neumayer, Koeppen, Koldeway, Schott, Boergen, Knipping, and others, at the Seewarte. The data from the logs of German vessels are accumulated in the archives of the Seewarte. They contain not merely the summary for the use of navigators, but laborious compilations, in clearly written text, by some of the ablest German scholars, and are well worthy of the study of other meteorologists.

The meteorology of the Pacific Ocean is considered in the last published handbook where we find two chapters on the winds; a chapter on the pressure of the air and its relation to the winds; a chapter on the temperature of the air and the rainfall; an elaborate treatment of the storms that have prevailed in various parts of the Pacific, preceded by a general introduction in which the whirlwinds and the squalls are distinguished from each other. We shall from time to time have occasion to quote from these three volumes of handbooks. At the present moment the following paragraphs on pages 178–179 of the volume for the Pacific Ocean seems appropriate:

DIURNAL VARIATION OF PRESSURE AND WIND.

The variations of the barometric pressure are partly periodic, that is to say, repeating themselves at regular intervals, and partly nonperiodic. The annual and the daily periods are prominent examples of these. The diurnal variation is of such remarkable magnitude and regularity in the tropics that it can not be neglected, since it constitutes a considerable fraction of the general oscillation. The pressure rises every day, with the regularity of the clock, from 4 a. m., local time, to 9:30 a. m., then it falls until 4 or 5 p. m.; then it again rises until 10 p. m. only to fall again until 3 or 4 a. m. The total extent of this daily oscillation amounts to two or three millimeters (viz, $\frac{1}{12}$ or $\frac{1}{8}$ of an inch). These oscillations have no relation to the weather. If, therefore, the barometer falls three millimeters, between 10 a. m. and 4 p. m., we are from that not to argue anything as to change in the weather, but we may indeed do so if during this time it had not fallen or has risen. Disturbances in the daily variation of the barometer, especially a fall between 4 and 10 a. m., or 4 and 10 p. m., are sometimes the first sign of a disturbance in the trade wind, or an approaching cyclone. Beyond the tropics the diurnal oscillation of the barometer is more and more obscured by the great irregular variations of pressure, and beyond 40° of north or south latitude the former plays practically no important role. The following small table contains some results of the bi-hourly observations on the Pacific Ocean made on the exploring voyage of the *Challenger;* each line is the mean of observations made during from ten to thirty-three days, during which the vessel did not materially change its geographic latitude. The figures indicate in millimeters and tenths how much the mean barometric pressure for the respective hours differed from the daily mean. Besides this double diurnal variation the accurate comparative observations demonstrate the presence of a simple diurnal oscillation which is different on the land and on the open ocean and which makes the pressure greater over the land than over the ocean during the nighttime, but greater over the ocean than over the land during the afternoon. The land and sea breezes owe their origin to this slight difference of pressure.

Diurnal variation of the barometer on the Pacific Ocean.

[Extracted and condensed from "Voyage of the Challenger," Vol. II, Part 5, A. Buchan, Table III, pp. 7-9.]

Latitude.	Longitude.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Midnight.
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
N. 36	E. 151 to W. 156....	−0.4	−0.4	0.1	0.4	0.5	0.3	−0.2	−0.4	−0.2	−0.1	+0.2	0.0
N. 22	E. 114, Hongkong .	−0.1	−0.3	0.1	1.0	1.3	0.5	−0.8	−1.1	−0.8	−0.1	0.2	0.3
0	E. 127, New Guinea	−0.4	−0.5	−0.1	0.9	1.1	0.2	−0.7	−1.1	−0.6	+0.1	0.7	0.2
S. 1	E. 147, New Guinea	−0.5	−0.8	0.1	1.0	1.2	0.5	−0.7	−1.0	−0.6	−0.1	0.5	0.4
S. 17	W. 150, Tahiti	−0.3	−0.5	0.1	0.7	0.9	0.3	−0.8	−1.2	−0.5	+0.2	0.6	0.5
S. 36	E. 158 to E. 167	−0.3	−0.6	−0.3	0.5	0.6	0.3	−0.4	−0.4	−0.2	+0.2	0.3	0.3
S. 37	W. 135 to W. 83....	−0.3	−0.6	−0.1	0.3	0.4	0.2	−0.1	−0.3	−0.1	+0.1	+0.3	+0.2
S. 50	W. 74, Patagonia .	−0.1	+0.2	0.6	0.4	0.2	0.0	−0.2	−0.3	−0.3	−0.4	−0.3	−0.1

Other facts that have been explained in Chapter IV show that in many cases another cause affects these diurnal variations of the wind more powerfully than this slight interchange of pressure between the land and ocean. Thus, for instance, on the leeward side of a small island (in the trade-wind belt) the land wind does not at nighttime replace the sea wind of the daytime, but calms occur in the nighttime, and powerful gusts of wind from the land in the daytime. In such cases we have to do with a phenomenon that is quite the same as occurs in the lowlands generally, where the general current of air (which at nighttime is to be found at an altitude of many hundred meters above the earth's surface, while at the earth's surface itself the air is held stagnant by the irregularities of the surface) is at midday, by the play of the ascending and descending movements above the heated soil, brought down to the latter in oft-repeated gusts. Many islands are too small to produce the true land and sea breezes; such, for example, is the case on the leeward side of the island of Oahu in the neighborhood of the city of Honolulu. On the other hand, the sea breeze occurs most powerfully where the general current of air that descends in gusts at the warmest time of the day, by reason of the vertical interchange, agrees in its direction with the sea wind that occurs about the same time, as, for example, at Valparaiso.

LOCAL WINDS OF HAWAII.

Chapter IV gives in detail the local peculiarities of the wind at prominent points on the coasts of continents and islands throughout the whole extent of the Pacific Ocean. Among these the following extract on pages 145–146, relative to the Hawaiian Islands, is translated as being apparently the item referred to:

The Hawaiian Islands lie somewhat to the south of the Tropic of Cancer, or the so-called horse latitudes. Corresponding to this location, the northeast trade wind blows almost uninterruptedly at this place during six months of the year, from May to October, inclusive. In December the polar limit of the steady trade winds has advanced southward from the island, and the struggle of the trade with the westerly winds begins and continues into March. The average number of days with trade winds, at Honolulu, for the years 1875–1889, were as follows:

January, 14; February, 15; March, 17; April, 21; May, 24; June, 26; July, 29; August, 30; September, 26; October, 22; November, 18; December, 16.

In the summer months, in the neighborhood of the islands, during the nighttime calms prevail, except in front of and in the passages between the islands. In the course of the forenoon the trade wind in the neighborhood of the land freshens until by midday it is generally strong, but in the afternoon gradually again diminishes. This is certainly the case on the lee side of the lower islands and portions of the islands, especially in the harbor of Honolulu; for the windward sides there is not yet enough data to speak positively. On the other hand, on the west side of Hawaii, the largest island, there is in the summer time a regular interchange of land and sea breezes. This, however, is only the case in localities where, on the windward side of the place, the mountain chain rises up so high that it cuts off the trade wind, which latter rarely extends beyond 2,400 meters. Above the plain of Waimea, which is only 900 meters high, to the north of the mountain of Mauna Kea (whose summit is 13,953 feet, according to Stieler's Hand Atlas), the trade wind blows overhead and strikes on the lee side as a dry, parching wind. South of this in the Kona District, directly to leeward of the high mountain of Mauna Kea, which cuts off the trade wind, the daily interchange of land and sea breezes occurs in the typical manner; at sunrise, calms prevail; about 10 o'clock the sea breeze sets in, blowing from the west, and gradually ascends the mountain sides; then, clouds rapidly form and soon there falls over the land rain that often continues till nighttime. About 9 or 10 p. m. the sea breeze ceases and shortly after that the descending land wind sets in; this is a dry wind; the clouds break away, the stars appear, the rest of the night is clear.

In the winter months the westerly winds of the Hawaiian Islands are caused by barometric depressions that pass in an eastward direction to the north of the islands. In such cases the wind begins to freshen up from the south and veers gradually to the southwest, many times accompanied by thunderstorms with cloudbursts of rain and not unfrequently increasing to a severe storm. After it has stormed for a while from this direction, the wind suddenly jumps to the northwest, then follows clearing-up weather, and soon after that the northeast trade again begins. The storm wind just described, which by the natives is called Kona, because it prevails principally on the Kona side, that is to say, the lee or the southwest side, has a duration of from a few hours to two or even three days. It is seldom strong enough on land to injure the houses, but occasionally interrupts navigation between the islands, as for example, in 1868. During the cruise of the English naval vessel *Petrel* among the Hawaiian Islands in September, October, and a part of November, 1875, the trade wind was often interrupted by southerly winds and calms with rain, except in the passages between the islands, where it seldom failed. On the west and southwest coast of Maui southeasterly winds prevailed, but which were occasionally replaced by the northeast trade which blows steadily over the isthmus of this island.

The island of Maui consists of a northwestern mountainous portion and a southeastern portion containing much higher mountains; between these is the connecting isthmus of comparatively low land to which the author of the Handbook evidently refers.

With regard to the depth of the layer of air involved in the movement of the northeast trade wind, the Handbook says:

On Mauna Loa and Mauna Kea, the two great mountains of the island of Hawaii, we do not generally find the trade wind blowing above 2,500 meters, no matter how strong it may be blowing below. From 2,500 up to 3,800 meters, calms prevail, and above that the current of wind has the opposite direction. In a corresponding manner the lower trade-wind clouds move from northeast to southwest, while the upper cirrus clouds move in the opposite direction, from southwest to northeast. The altitudes from 1,100 to 2,100 meters, are almost always on Hawaii enveloped in clouds, but from the upper portion of Mauna Loa (altitude, 13,760 feet) one looks out upon a sky that is always clear in summer and of wonderful purity. The summit of Haleakala, on the island of Maui, more than 160 kilometers distant toward the northwest, appears sharp and clear above the ocean of clouds, like a dome above a field of snow. The storms that prevail on these peaks appear to come from the southwest or the northwest.—[C. A.]

MEXICAN CLIMATOLOGICAL DATA.

Through the kind cooperation of Señor Mariano Bárcena, Director, and Señor José Zendejas, vice-director, of the Central Meteorologico-Magnetic Observatory, the monthly summaries of Mexican data are now communicated in manuscript, in advance of their publication in the *Boletin Mensual;* an abstract translated into English measures is here given in continuation of the similar tables published in the MONTHLY WEATHER REVIEW during 1896. The barometric means have not been reduced to standard gravity, but this correction will be given at some future date when the pressures are published on our Chart IV.

Mexican data for September, 1897.

Stations.	Altitude.	Mean barometer.	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
	Feet.	*Inch.*	° *F.*	° *F.*	° *F.*	%	*Inch.*		
Arteaga (Coahuila)	......	......	88.9	58.6	70.2	......	0.55	......	......
Barousse	5,414	......	78.4	59.2	67.6	......	0.75	......	......
Colima	1,656	......	...	......	79.3	......	......	......	......
Durango	6,241	24.10	80.6	45.0	66.2	51	1.82	......	e.
Leon	5,934	24.34	80.1	43.0	65.1	66	2.44	ene.	e.
Linares (New Leon)	1,188	......	91.4	51.8	71.4	71	3.27	......	......
Magdalena (Sonora)	4,948	......	......	......	81.1	......	5.55	ne.	ne.
Merida	50	29.89	96.6	67.1	80.8	77	1.69	n.	w.
Mexico (Obs. Cent.)	7,472	23.11	75.6	44.6	59.9	71	5.62	nw.	ne.
Mexico (E. N. de S.)	......	23.09	80.2	46.4	61.9	66	5.91	ne.	......
Monclova (Coahuila)	1,926	......	91.0	64.6	81.9	......	0.55	......	......
Monterey	1,626	28.27	91.9	54.0	76.1	72	5.40	e.	se.
Morelia (Seminario)	6,401	24.01	78.2	46.9	58.5	77	5.73	ne.	e.
Oaxaca	5,164	25.10	84.2	48.4	68.0	75	3.68	nw.	e.
Parras (Coahuila)	3,966	......	80.8	60.6	68.5	......	1.50	......	......
Puebla (Col. Cat.)	7,112	23.40	79.5	38.3	67.5	59	7.00	......	......
Queretaro	6,070	24.24	77.0	45.9	63.7	66	3.30	e.	......
Saltillo (Col. S. Juan)	5,399	24.89	84.7	49.1	67.8	62	0.47	w.	se.
San Luis Potosi	6,202	24.16	74.7	47.7	63.7	70	1.38	e.	se.
Sierra Mojada (Coah)	......	......	96.4	54.0	75.0	......	0.28	......	......
Torreon (Coahuila)	3,720	......	95.4	65.1	81.3	......	1.38	......	......
Vaqueria (Coahuila)	......	......	83.1	50.5	66.9	......	3.86	......	......
Zacatecas	8,015	22.57	74.3	40.3	61.3	71	3.89	e.	e.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

For text descriptive of tables and charts see page 357 of REVIEW for August, 1897.